

POLYAXIAL BONE SCREW WITH SPLIT RETAINER RINGBackground of the Invention

1 The present invention is directed to a bone screw of
2 the type wherein a head of the bone screw is swingable or
3 can swivel about the shank of the bone screw until the
4 surgeon is satisfied with the relative placement of the two
5 parts and thereafter the head can be locked in position
6 relative to the shank. Such screws are also referred to as
7 polyaxial head or swivel head bone screws, since the head
8 can be positioned in any of a number of angular
9 configurations relative to the shank.

10 Bone screws are advantageously utilized in many types
11 of spinal surgery in order to secure various implants to
12 vertebrae along the spinal column. Bone screws of this type
13 typically have a shank that is threaded and adapted to be
14 implanted into a vertebral body of a vertebra. The bone
15 screw includes a head which is designed to extend beyond the
16 vertebra and which has a channel to receive another implant.
17 Typically the channel will receive a rod or a rod-like
18 member. In bone screws of this type, the head may be open,
19 in which case a closure must be used to close between

1 opposite sides of the head once a rod-like implant is placed
2 therein, or closed wherein a rod-like implant passes through
3 the head of a bone screw. Open head screws are most often
4 used, mainly because it is difficult to feed long rods
5 through closed head screws.

6 Bone screws are also available with heads permanently
7 fixed relative to a shank or with polyaxial heads that
8 initially swivel to allow placement and are then lockable in
9 a desired positional configuration. When the head and shank
10 of the bone screw are fixed in position relative to each
11 other, it is not always possible to insert a bone screw into
12 the bone in such a manner that the head will be in the best
13 position for receiving other implants. Consequently, the
14 polyaxial head bone screws have been designed that allow the
15 head of the bone screw to rotate or swivel about an upper
16 end of the shank of the bone screw, while the surgeon is
17 positioning other implants and finding the best position for
18 the bone screw head. However, once the surgeon has
19 determined that the head is in the best position, it is then
20 necessary to lock or fix the head relative to the shank.
21 Different types of structures have been previously developed
22 for this purpose. Unfortunately, the prior art devices have
23 a tendency to be bulky, slip under high loading or require
24 many parts.

1 It is desirable to have a polyaxial head bone screw
2 that can be captured by the shank prior to locking of the
3 head, but that allows the head to freely swivel or pivot
4 about a top of the shank prior to locking. It is then
5 further desirable to have the head capable of being fixably
6 locked in a configuration or position relative to the shank
7 where the head best fits with other elements of the overall
8 spinal implant.

9 As noted above, many prior art swivel type bone screws
10 have a bulky and heavy structure. In spinal surgery, it is
11 desirable to provide a light weight implant that impacts on
12 the surrounding tissue as little as possible. Consequently,
13 it is desirable to have a bone screw with a low profile with
14 respect to both height and width. It is also preferable to
15 limit the width profile of the bone screw to provide more
16 room to work along a rod or other implant in which many
17 elements may be required in a relatively small space.

18 Furthermore, it is desirable to maintain the number of
19 parts of the device at a minimum. Also, it is desirable to
20 secure the various parts together in such a way, so that, if
21 parts become loose under use for some reason, the device
22 will not totally disassemble.

1 Summary of the Invention

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3 The present invention provides an improved polyaxial
4 head bone screw assembly for use in conjunction with spinal
5 surgery and, in particular, for implanting into a bone and
6 securing other medical implants to the bone. The polyaxial
7 bone screw assembly includes a threaded shank member for
8 threaded placement in a bone, a head member connecting to
9 another implant such as a spinal fixation rod and capturing
10 a capture end of the shank member, and a retainer ring to
11 capture and retain the capture end of the shank member
12 within the head member. The shank member and head member
13 may be set in a plurality of angular relationships with
14 respect to each other within a range of obtuse angles.

15 The shank or shank member has an outer portion which is
16 threaded, sized and shaped so as to be adapted to be
17 operably screwed into a vertebral body in the spine of a
18 patient. An end of the shank opposite the threaded lower
19 portion includes a frusto-conical capture structure which
20 diverges in diameter in a direction away from the threaded
21 end of the shank. A top of the conical capture end is
22 provided with apertures or formations for non-slip
23 engagement by an installation tool to enable the shank to be
24 threaded into a bone, such as a vertebra. Beyond the

1 conical structure, a knurled dome is provided for positive
2 interfering or cutting engagement by the surface of a rod
3 which is to be clamped and supported by the bone screw
4 assembly.

5 The head member is generally partially cylindrical in
6 outer shape and has a central axial bore to receive the
7 capture end of the threaded shank and a central U-shaped
8 cradle opens in a direction opposite the axial bore to
9 receive a spinal fixation rod and presents a pair of spaced
10 apart arms. An interior of each of the arms includes
11 threads to receive a threaded plug to secure the rod within
12 the cradle and to clamp the rod into engagement with the
13 knurled dome of the shank to fix the angular position of the
14 head with respect to the shank. The head includes a lower
15 partially spherical socket or seat at the lower end of the
16 axial bore for receiving the ring and forms a neck for
17 surrounding the shank during usage.

18 The retainer ring has an outer surface which is
19 partially spherical and which is sized and shaped to fit
20 within and swivel within the seat until locked in position,
21 as noted below. The ring also has a central bore which is
22 frusto-conical and of a shape which is compatible with the
23 capture end of the shank to snugly receive the shank
24 therein. The ring is sized to be too large in width to fit

1 through the neck at the bottom of the head when in operable
2 position and is either loaded from the top of the head or
3 through other structure formed in the head. The ring is
4 resiliently expandible to enable the ring to be snapped over
5 the capture end of the shank to retain the capture end
6 within the head member. The head has an assembly or
7 orientation cavity therein which communicates with the U-
8 shaped cradle and which is positioned and sized to enable
9 proper orientation of the retainer ring and engagement of it
10 with the capture end of the shank. The assembly cavity is
11 spaced axially above the seat and neck and has a slightly
12 larger partial spherical diameter than the seat so as to
13 allow the ring to expand during insertion of the shank
14 capture end and then return to a smaller diameter for snugly
15 fitting in the seat. The spherical seat initially forms a
16 pivot bearing with the retainer ring, when no axial downward
17 force is applied to the shank and ring, to retain the
18 capture end of the shank within the head and to enable
19 pivoting the shank relative to the head throughout a limited
20 range. The retainer ring is formed of a resilient or
21 springy material and in a preferred embodiment has a radial
22 split to enable expansion of the diameter of the ring and,
23 particularly, to enable expansion of the diameter of the

1 central bore to enable placement on the conical capture end
2 of the shank.

3 Once the ring is on the shank and located in the seat
4 in a position suitable to the surgeon with a rod received in
5 the head channel, a closure plug is screwed into the threads
6 between the arms so as to engage the rod and urge the rod
7 under pressure into engagement with the dome on the shank.
8 This in turn urges the spherical surface on the ring into
9 frictional engagement with the spherical surface of the seat
10 so as to lock the rotational position of the shank relative
11 to the head. The dome of the shank is preferably radiused
12 so that it engages the rod in the same manner no matter what
13 alignment is formed between the head and the shank. The
14 dome also preferably has a radius that is substantially less
15 than the radius of the partial spherical surface of the
16 ring. This reduces the required height of the head in
17 comparison to the dome that is a continuation of the
18 spherical surface.

19 Preferably, the shank feeds into the head from below
20 through the neck of the head and has a smaller diameter in
21 the region of the capture end than the diameter of the
22 threads. This allows the shank to have a comparatively wide
23 and normal thread for screwing into the bone that may be
24 wider than the neck of the head, while also allowing the top

1 of the shank to pass through the neck of the head to connect
2 with the retainer ring.

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5 Objects and Advantages of the Invention

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7 Therefore, the objects of the present invention
8 include: providing an improved bone screw assembly for
9 implantation into a vertebra of a patient wherein the head
10 of the bone screw is swingable or swivelable about an end of
11 a shank of the bone screw until a desired configuration is
12 obtained after which the head is lockable in position
13 relative to the shank; providing such a screw assembly
14 including a threaded shank with a capture end, a head member
15 with a shank receiving bore and a U-shaped rod cradle for
16 receiving a spinal fixation rod, a resiliently expandible
17 shank retainer ring to retain the capture end of the shank
18 within the head, and a threaded plug receivable in the head
19 to engage a cradled rod and urge it into securing engagement
20 with the capture end of the shank to fix the angular
21 position of the shank relative to the head; providing such a
22 screw assembly wherein the head member includes an internal
23 partial spherical cavity, socket or seat and the retainer
24 ring includes a partial spherical outer surface to enable

1 swiveling and universal positioning of the shank relative to
2 the head member from side to side and front to rear within a
3 limited range; providing such a screw assembly in which the
4 head member includes an assembly or orientation cavity above
5 the seat to enable expansion of the ring during joining with
6 the shank and proper orientation of the retainer ring;
7 providing such a screw assembly in which the retainer ring
8 has a radial split to enable resilient expansion and
9 retraction of the ring for snapping the ring onto the
10 capture end of the shank; providing such a screw assembly in
11 which the capture end of the shank is frusto-conical,
12 diverging in diameter in a direction away from the threaded
13 part of the shank and in which the retainer ring has a
14 central bore which is compatibly frusto-conical in shape;
15 providing such a screw assembly in which the capture end of
16 the shank has a knurled dome for positive, interfering
17 engagement by a spinal fixation rod clamped within the
18 assembly and wherein the dome has a radius that is smaller
19 than the radius of the ring partial spherical surface; and
20 providing such a polyaxial head bone screw which is
21 economical to manufacture, which is convenient and secure in
22 use, and which is particularly well adapted for its intended
23 purpose.

1 Other objects and advantages of this invention will
2 become apparent from the following description taken in
3 conjunction with the accompanying drawings wherein are set
4 forth, by way of illustration and example, certain
5 embodiments of this invention.

6 The drawings constitute a part of this specification
7 and include exemplary embodiments of the present invention
8 and illustrate various objects and features thereof.

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10 Brief Description of the Drawings

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12 Fig. 1 is an enlarged cross sectional view of a
13 polyaxial head screw with a split retainer ring which
14 embodies the present invention, shown assembled with a rod
15 to hold the rod and inserted in a vertebral bone.

16 Fig. 2 is an exploded perspective view of elements of
17 the bone screw at a reduced scale and illustrates a threaded
18 shank member, a head member, and a retainer ring.

19 Fig. 3 is an enlarged cross sectional view of the screw
20 head and illustrates the orientation of the split retainer
21 ring for insertion into the head.

22 Fig. 4 is a view of the screw head similar to Fig. 3
23 and shows the orientation of the retainer ring to prepare
24 for insertion of a capture end of a threaded shank.

1 Fig. 5 is a view similar to Fig. 3 and shows the
2 retainer ring about to be snapped onto the capture end of
3 the threaded shank.

4 Fig. 6 is a view similar to Fig. 3 and shows the
5 retainer ring positioned on the capture end of the threaded
6 shank.

7 Fig. 7 is a view similar to Fig. 3 and shows the
8 capture end of the shank with the installed retainer ring
9 positioned in a spherical pivot seat of the screw head.

10 Fig. 8 is a view similar to Fig. 3 and shows the
11 threaded shank with retainer ring pivoted to a selected
12 angle relative to the screw head.

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14 Detailed Description of the Invention

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16 As required, detailed embodiments of the present
17 invention are disclosed herein; however, it is to be
18 understood that the disclosed embodiments are merely
19 exemplary of the invention, which may be embodied in various
20 forms. Therefore, specific structural and functional
21 details disclosed herein are not to be interpreted as
22 limiting, but merely as a basis for the claims and as a
23 representative basis for teaching one skilled in the art to

1 variously employ the present invention in virtually any
2 appropriately detailed structure.

3 Referring to the drawings in more detail, the reference
4 numeral 1 generally designates a polyaxial bone screw
5 arrangement which embodies the present invention. The
6 arrangement 1 includes a threaded shank member 2 for
7 threadably implanting into a bone 3, such as a vertebra, and
8 a head member 4 which connects with the shank member 2 to
9 engage and secure a rod member 5, such as a spinal fixation
10 rod, relative to the bone 3. The arrangement 1 also
11 includes a retainer ring 7 operably positioned within head 4
12 and engaging a capture end 9 of the shank 2 opposite a
13 region having a thread 8 to retain the capture end 9 within
14 the head 4. The arrangement 1 further includes a plug or
15 closure member 10 which urges the rod 5 into engagement with
16 the capture end 9 of the shank 2. The head 4 and shank 2
17 cooperate in such a manner that the head 4 and shank 2 can
18 be secured at any of a plurality of obtuse angles, relative
19 to one another and within a selected range of angles both
20 side to side and front to rear, to enable flexible
21 engagement of the arrangement 1 with a rod 5.

22 Referring to Figs. 1, 2, and 5, the shank 2 is
23 elongated and is sized and shaped to be screwed into one of
24 the vertebra 3. The shank 2 includes the external helically

1 wound thread 8 that extends from an outer tip 12 to near the
2 capture end 9. On the illustrated shank 2, the capture end
3 9 includes a region that is frusto-conical in shape,
4 diverging in diameter in a direction away from the outer tip
5 12 and that is coaxially aligned with an axis of the shank
6 2. The illustrated capture end 9 has a maximum radius that
7 is substantially less than a radius associated with the
8 shank thread 8 and further, preferably less than the radius
9 of a body 13 of the shank 2 in the region whereupon the
10 thread 8 is located.

11 The capture end 9 has a plurality of tool engageable
12 grooves, apertures or the like 14 to enable positive
13 engagement by an appropriately shaped installation tool (not
14 shown) to thread and drive the shank 2 into the vertebra 3.
15 An upper end surface 16 of the capture end 9 opposite the
16 tip 12 is provided with a formation or dome 18 to be
17 positively and interferingly engaged by the rod 5 when the
18 assembly 1 is assembled into place. The illustrated shank 2
19 includes the dome 18 which is radiused and knurled and that
20 centered on the upper end surface 16 of the shank capture
21 end 9 so as to be coaxial with the remainder of the shank 2.
22 The scoring or knurling of the dome 18 operably frictionally
23 abuts against a cylindrical surface 20 of the rod 5, when
24 the plug 10 is tightened to provide non-slip engagement of

1 the shank 2 relative to the rod 5 and to thereby help
2 maintain a desired angular relationship between the shank 2
3 and the head 4. In certain embodiments, the purpose of the
4 dome 18 is simply to be engaged by the rod 5 during assembly
5 and pushed in such a manner as to frictionally engage the
6 ring 7 with the head 4 as described below. Preferably, the
7 dome 18 is radiused so that the dome 18 engages the rod at
8 the same location even as the head 4 is swivelled relative
9 to the shank 2. However, in certain embodiments the dome 18
10 could have other shapes.

11 Referring to Figs. 2-8, the head member 4 is generally
12 cylindrical in external profile and has a central and
13 axially aligned shank receiving bore 24 ending at an inner
14 and lower neck 26. The neck 26 is radiused to receive the
15 shank capture end 9 and preferably smaller than the radius
16 of the shank body 13 and thread 8. The bore 24 is also
17 preferably sized larger than the capture end 9 of the shank
18 2 to enable the shank 2 to be oriented through a range of
19 angular dispositions relative to the head 4. The bore 24
20 may be conically counterbored or beveled in a region 28 to
21 widen the angular range of the shank 2.

22 The head 4 is provided with a U-shaped rod cradle 30
23 which is sized to receive the rod 5 therethrough. The
24 illustrated cradle 30 is rounded and radiused at an inner or

1 lower portion 31 to snugly mate with the surface of the rod
2 5 and open at an outer end 33, with spaced apart parallel
3 side surfaces 32 so as to form upstanding and spaced apart
4 arms 35 with inwardly facing threading thereon. The side
5 surfaces 32 have mating and guide structures 34 formed
6 thereinto which are complementary to mating and guide
7 structures 36 of the closure plug 10 (Fig. 1). The
8 structures 34 and 36 may be helically wound flanges or
9 threads which advance the plug 10 into the head 4, as the
10 plug 10 is rotated about its axis. It is foreseen that
11 structures 34 and 36 may be V-shaped threads, buttress
12 threads, reverse angle threads, or other types of threads or
13 flange forms. Preferably, the structures 34 and 36 are of
14 such a nature as to resist splaying of the arms 35 when the
15 plug 10 is advanced into the cradle 30.

16 As seen in Figs. 3 and 4, the head 4 has an assembly
17 cavity 38 formed therein which opens into the cradle 30. A
18 partially spherical socket or seat 40 communicates between
19 the assembly cavity 38 and the shank bore 24 and has a
20 radius that is slightly less than the radius of the assembly
21 cavity 38 that is located axially directly thereabove. The
22 purposes for the cavity 38 and seat 40 will be detailed
23 further below. The head 4 may include external, closed end
24 grip bores 42 for positive engagement by a holding tool (not

1 shown) to facilitate secure gripping of the head 4 during
2 assembly of the arrangement 1. The seat 40 has a spherical
3 radius and extends upward coaxially through the head 4 from
4 the neck 26 to the cavity 38.

5 The closure plug 10 is generally cylindrical in shape
6 and is provided with a break-off head 44 which is connected
7 to the plug 10 by a weakened area such that the head 44
8 separates from the plug 10 at a predetermined torque applied
9 to the head 44 during assembly. The illustrated break-off
10 head 44 has a hexagonal cross section for engagement by a
11 tool (not shown) of a complementary shape.

12 The retainer ring 7 is used to retain the capture end 9
13 of the shank member 2 within the head member 4. The
14 retainer ring 7 resiliently expands and contracts to enable
15 the ring 7 to be snapped over and seated on the capture end
16 9 of the shank 2. The ring 7, like the remainder of the
17 arrangement 1, is preferably formed of a material such as a
18 spring stainless steel, tantalum, titanium or other
19 resilient implantable material. The illustrated ring 7 has
20 a radial split 48 which allows the ring 7 to expand in
21 circumference to fit over the capture end 9. Alternatively,
22 other configurations of the ring 7 are envisioned to enable
23 such expansion and retraction of the ring 7. The ring 7 has
24 a central conical bore 50 which is conically shaped to be

1 compatible with the conical shape of the capture end 9. The
2 ring 7 has an outer surface 52 which is frusto-spherical,
3 partially spherical, or a segment of a sphere, and which has
4 a spherical radius approximately equivalent to the spherical
5 radius of the spherical seat 40 within the head 4 and
6 smaller than the radius of the cavity 38. The ring surface
7 52 also has a radius substantially greater than the dome 18.

8 Figs. 3-8 illustrate step by step assembly of the
9 components of the bone screw arrangement 1. In Fig. 3, the
10 ring 7 is inserted into the head 4 through the interior of
11 the U-shaped cradle 30. The ring 7 is oriented with its
12 axis at a right angle to the axis of the bore 24 and to the
13 side surfaces 32 of the cradle 30. Fig. 4 illustrates the
14 ring 7 oriented with its axis parallel or coincident with
15 the axis of the bore 24 and neck 26, by rotating the ring 7
16 within the assembly cavity 38. In Figs. 5 and 6, the
17 capture end 9 of the shank 2 is inserted through the bore 24
18 and engaged with the retainer ring 7 so as to snap the ring
19 7 over the capture end 9. This is accomplished by pressing
20 the shank 2 into the head 4, causing the ring to engage a
21 constriction at the top of the assembly cavity 38. The
22 relative resistance encountered by the ring 7 allows the
23 capture end 9 to expand the circumference of the retainer
24 ring 7, by expansion of the split 48, so that the capture

1 end 9 enters the central bore 50 of the ring 7. The capture
2 end 9 includes a shoulder 56 which limits penetration of the
3 capture end 9 into the retainer ring 7, as shown in Fig. 6.

4 Fig. 7 shows the arrangement 1 with the retainer ring 7
5 lowered from the assembly position and positioned in the
6 spherical seat 40 and the central axis of the shank 2
7 coaxial with the central axis of the head 4. Fig. 8 shows
8 the shank 2 angled relative to the head 4. The spherical
9 seat 40 and spherical outer surface 52 of the retainer ring
10 7, when seated in the seat 40, allows universal angular
11 positioning of the shank 2 relative to the head 4 within a
12 limited range, as is shown in Fig. 8. The retainer ring 7,
13 thus, performs the double functions of preventing the
14 capture end 9 of the shank 2 from slipping through the neck
15 26 and, in conjunction with the seat 40, forms a ball joint
16 for relative orientation of the shank 2 and head 4.

17 Under some circumstances, it may be desirable to
18 assemble the shank 2 and head 4, prior to threading the
19 shank 2 into the vertebra 3 or other bone. Thereafter, the
20 shank 2 may be conveniently screwed into the vertebrae 3 by
21 passing the installation tool through the cradle 30 to
22 engage the grooves 14 of the capture end 9. The vertebra 3
23 may be predrilled with a pilot hole or the like (not shown)
24 to minimize stressing the bone 3. Once the shank 2 has been

1 threaded to its desired depth, the head 4 can be oriented as
2 desired. The rod 5 is positioned in the cradle 30, engaging
3 the knurled dome 18, and the closure plug 10 is advanced
4 into the head 4 to clamp the rod 5 between the capture end 9
5 and the closure plug 10. When the preset torque limit of
6 the plug 10 is reached, the break-off head 44 separates from
7 the closure plug 10. The force transmitted by torquing of
8 the closure plug 10 transmits through the rod 5 and through
9 the dome 18 to the ring 7. The partial spherical surface 52
10 of the ring 7 is thereby urged into tight frictional
11 relationship with the partial spherical surface 40 of the
12 head 4, thereby locking the angular configuration of the
13 head 4 relative to the shank 2.

14 It is to be understood that while certain forms of the
15 present invention have been illustrated and described
16 herein, it is not to be limited to the specific forms or
17 arrangement of parts described and shown.

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